MAPPING CONSTRUCTION OF SOIL VARIABILITY WITHIN THE LANDSCAPE

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ABSTRACT

The research aimed to construct mapping soil variability within the landscape. The research was located in Central Lampung (308 ha). The survey type was detailed using topographic maps (scales of 1:5,000) and the aerial photo interpretations. The soil samples were performed by soil pits and borings for whole survey area (1 composite sample/ha), classified and analyzed. The balancing methods used transect diagrams, delineated soil bodies and area point statistics. The research resulted that the aerial photo interpretation was a very useful method to delineate soil units on the map. A combination of aerial imagery, topographical maps and field observations provide the most effective approach for soil mapping in complex landscapes with simple soil patterns. Although the soil sampling was carried out relatively systematic according to relief form and the driving lanes of tractors, there was some agreement between point statistics and map data. The difference between both methods was maximally 3 %. The result combination from both methods shows that 60 % of the landscape was classified as eroded, 35 % as normal and 5 % as colluviated. There was no balance of erosion and onsite sedimentation.

Keywords : Construction, landscape, mapping, soil variability

KONSTRUKSI PEMETAAN KERAGAMAN TANAH DALAM SUATU BENTANG LAHAN

ABSTRAK

Penelitian ini bertujuan untuk mengkonstruksi pemetaan keragaman tanah dalam suatu bentang lahan. Lokasi penelitian terletak di Lampung Tengah (308 ha) dan tipe survai yang digunakan adalah detil dengan peta topografi skala 1:5.000 dan interpretasi foto udara. Sampel tanah komposit (1 sampel komposit/ha) diambil di profil dan boring untuk seluruh areal, kemudian dilakukan klasifikasi dan analisa tanah di labor. Metode keseimbangan dengan cara diagram transek, deliniasi tubuh tanah dan areal point statistik. Hasil penelitian menyimpulkan bahwa interpretasi foto udara merupakan metode yang sangat bermanfaat untuk mendeliniasi unit tanah pada peta. Kombinasi image foto udara, peta topografi dan observasi lapang merupakan pendekatan paling efektif untuk pemetaan bentang lahan menjadi pola-pola tanah sederhana. Walaupun sampel tanah diambil secara sistematik menurut bentuk relief dan lajur traktor, ternyata ada keselarasan antara hasil dari point statistik dengan data peta. Perbedaan kedua metode di atas maksimal 3 %. Berdasarkan kombinasi kedua metode itu, maka dapat dihitung bahwa 60 % dari bentang lahan tererosi, 35 % normal dan 5 % tersedimentasi. Tidak terdapat keseimbangan antara areal tererosi dengan areal tersedimentasi.

Kata kunci : Bentang lahan, keragaman tanah, konstruksi, pemetaan

INTRODUCTION

One of important problems in agricultural intensification is inaccurate fertilization and pesticides use. This was proved that agricultural land fertilization in the world increased significantly, i.e. P fertilizer dosage increased from 5 kg P/ha in 1910, 30 kg P/ha in 1991 and > 50 kg P/ha in 2000 (assumed). However, agricultural yields increased not linear with increasing fertilization (Finck, 1992). Exceeded application of fertilizer and pesticides in soils caused pollution on water and land. It is becoming a serious problem if buffering, filtering and transforming of soils are not really understood.

To solve the above problem, soil capacity to adsorb soil nutrients and their distributions in form of soil maps should be known. Agricultural managers need such soil maps in order to solve the problems in the fields (Young *et al.*, 1997, Darmody *et al.*, 2000). Generally, they use them for references, planning, management and analytical tools. In Indonesia map utility for agricultural purposes is still limited not only in its construction, but also in understanding the maps themselves (Darmawijaya, 1992). To construct useful soil maps, the spatial variability of soils within the landscape must be identified and understood (Gobin et al., 2000, Gessler *et al.*, 2000, Lee *et al.*, 2001). Therefore, this research aimed to construct mapping soil variability within the landscape.

MATERIAL AND METHOD

The research site was located in Central Lampung, 90 km north of Teluk Betung and lies at elevations in a range between 6-37 m a.s.l. Most of slopes have lengths of 300-700 m with a mean value of 500 m. The slope steepness was 2-20 % with a mean value of 8 %.

The survey type was detailed using topographic maps with scales of 1:5,000. The soil recording and sampling were performed by soil pits and borings for whole survey area (1 composite sample/ha). The composite soil samples were taken using a boring instrument at the depth of 0-20 cm, 20-35 cm, 35-60 cm, 60-90 cm and 90-120 cm and analyzed in laboratory for pH and available P. The field's descriptions of pits, borings and landscapes were generally divided into two categories:

- General field descriptions according to FAO (1977) standards (vegetation, land use, climate, elevation, relief form, and profile descriptions). Finally, the pits and landscapes were photographed. Specific descriptions (designation of horizon depths, soil colors, mottles, depths of krokos, bulk density, gravel content, texture and roots).
- Classification of soils were tested on all individual soil descriptions corresponding to the analytical data and relief form with the help of image interpretations of remote sensing (Soil Survey Staff, 1998).

Erosion and sedimentation classification was determined in the fields according to literature that erosion rate of < 10 t/ha in a year was almost similar to soil genesis of Krakatau volcanic ashes, around 8-10 t/ha in a year (Hardjowigeno, 1987). The parent material of survey area was also Krakatau volcanic ash. Summary of erosion and sedimentation classification was presented completely in Table 1.

Table 1 Erosion and sedimentation classification in research area

Erosion rate (t/ha in a year)	Criteria	Sedimentation rate (t/ha in a year)	Criteria
< 10	Normal	< 10	Normal
10 – 20	Weak	10 – 20	Weak
20 – 30	Moderate	20 – 30	Moderate
> 30	Strong	> 30	Strong

The landscape balance was carried out in the landscape based on the surface soils and M-horizons. There are three principal methods for this balancing, e.g. using diagrams of transect, delineated soil bodies and aerial point statistics (Figure 1).

- Calculation of transect balance uses eroded sites in hilltops and flat area (no erosion expected). The mass difference of both positions is compared to forest profiles also in hilltops as the control. The average result of three transect balances gives the average erosion degree in the landscape.
- The delineated soil bodies show the balance of eroded and colluviated area. The losses of soil mass are counterbalanced by the colluviated soils if the soil system is closed.
- The areal point statistics also give the probability of colluvia occurrences. It was developed using a simple quantitative model of erosion degree and

trend of landscape. The simplest approach is to use point statistics of colluvia occurrences.

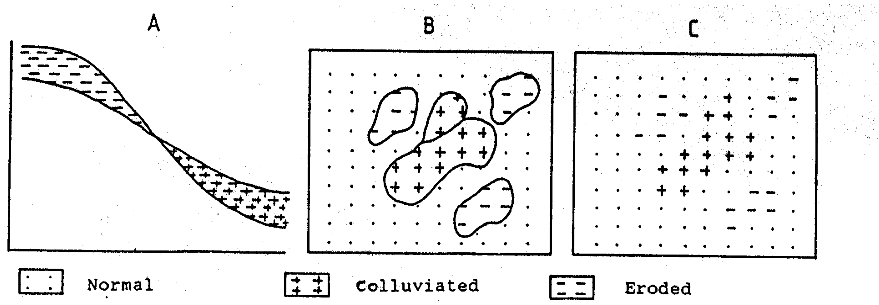

Figure 1. General principal of landscape analyses
(A: Transect Diagram, B: Delineated Soil Bodies, C: Areal Point Statistics)

RESULTS AND DISCUSSION

Interpretation of Air Photo Images

This discussion aims to judge the usefulness of remote sensing data for soil variability investigations, especially for erosion indicators in the landscape. Aerial photos portray much information and simplify the determination and drawing of soil boundaries, especially if they are combined with topographical maps. Therefore, time is saved in field work and the quality of mapping is improved.

The detection of soil variability was carried out for distributions of erosion and colluviation. The erosion and colluvium boundaries were proved by overlaying a transparent topographic map on the aerial photo. The key for detection of erosion and the results from image interpretations are presented in Table 2. A delineation projection onto a photocopied used gray tone image. While constructing the soil map all observation points from borings and profile pits were checked. Laboratory data as well as field descriptions were included in this crosschecking and evaluation process, which is based on landscape genesis and physiographic principles. Finally, the soil bodies are delineated as mapping units and described by legends.

Table 2 The detection key for erosion and net colluviation

Gray tone*)	Landscape position	Traces

			Interpretation
Light	hilltops - upper slopes	faint	Strongly eroded
Light-gray	hilltops - middle slopes	yes	Moderately eroded
Gray	middle - lower slopes	clear	Normal
Dark-gray	depressions-lower slopes	yes	Medium colluviated
Black	depressions	faint	Strongly colluviated

Note : *) Relative ratings, gray tones may vary appreciably depending on soil texture, structure, moisture and crop phenology.

Eroded sites are shown by the air photo with enlighted colors for A-horizons and colluviated sites with dark colors. The intensity of light and dark combinations is evaluated as a degree of colluviation or decapitation. The color degree on the air photo is differentiated into six categories, as follows:

- A light site is interpreted with high probability as a decapitated or eroded site if it is located on hilltops to upper slopes
- A dark-light site in upper positions is associated as a low decapitated area
- A light-dark area is classified as a low eroded and colluviated (normal) site, especially if it is situated on plateaus or middle slopes
- A dark site at lower slopes is interpreted as a colluviated site and
- A very dark site is classified as a peat soils, highly colluviated or a forest if it is situated in depressions.

There exists a close correlation between aerial photo interpretation, soil morphological descriptions, and the visible features of land form and vegetation. The detailed soil descriptions give crosschecking possibilities and help to classify the soils according to their genesis and morphological properties. Soil borings are relatively difficult to use for defining and outlining soil associations in the landscape, but aerial photo interpretation provides high possibilities to do so. A combination of both methods avoids over interpretation of soil classification and morphological field description. On the other hand, misinterpretations of aerial imagery can be also corrected by field descriptions. Attempts to identify erosion from aerial photos directly can successfully be done because the surveyor knows the landscape well. But a field controlled extrapolation to identify soil variability and high quality and characteristic photo-imagery is necessary.

Soil Variability Map

The soil map is relatively simple and has simple patterns mainly due to relief and erosion. The areal extent of soil subgroups is shown by the soil map in Figure

2, which reveals significant changes of soil subgroups within medium distances. No balance of eroded and colluviated soils exist. Kanhapludults dominate in central positions from north to south. Dystropepts are found in area between Kanhapludults and Aquepts in the middle of both islands. Next to Kanhapludults are oxic Dystropepts with a krokos depth of < 80 cm, oxic Dystropepts and aquic Dystropepts, respectively. Tropaquepts lie around Dystropepts and Humaquepts. Humaquepts are found along the rivers. These changes are functions of relief conditions.

Comparison of Soil Erosion Indicating Taxonomic Units

The erosion map was made with the help of the erosion indicators and interpretation of air photo Images presented in Figure 3. The extent and distribution of erosion in the landscape shows that 62 % of the total area is classified as eroded soils, 34 % is classified as normal soils and 4 % belongs to colluviated soils. This indicates that only 4 % of eroded materials could be colluviated in the landscape, whereas > 90 % was transported into the rivers (Table 3).

Table 3 Extent of Erosion and Colluvium

Erosion/colluviation rating	ha	%
Strong - moderately eroded	148	48
Weakly eroded	43	14
Normal	105	34
Weakly colluviated	9	3
Strong-moderately colluviated	3	1
Total	308	100

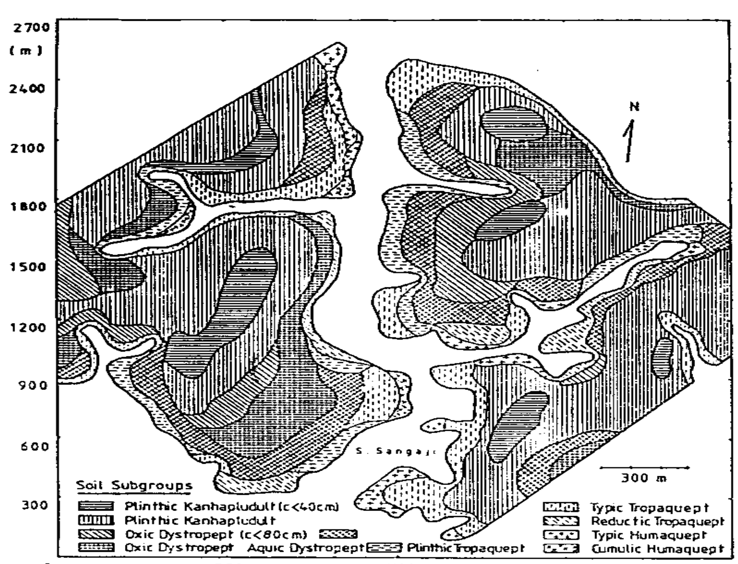

Figure 2. A map of soil variability

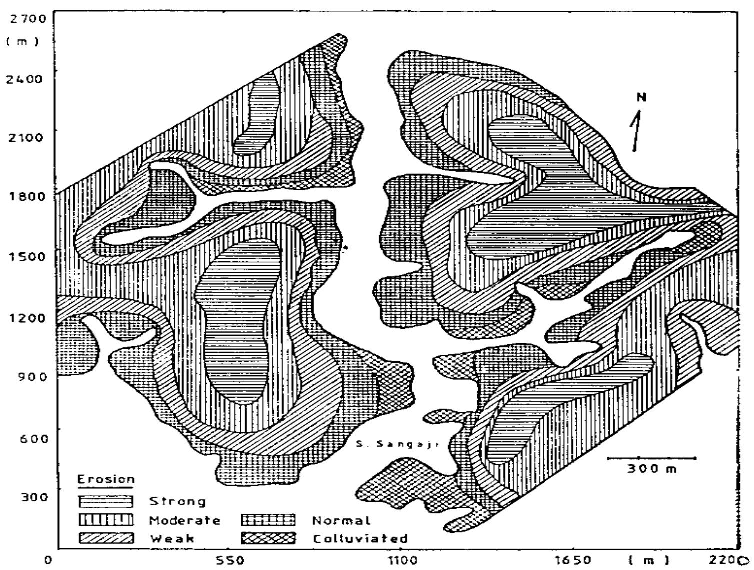

Figure 3 Amap of soil erosion distribution

Comparison of Map Data with Point Statistics

Comparing the taxa extent of soil maps with those from point statistics proved whether the overall statistical estimations from point samples (N= 308) represented the mapped soil units from the complex construction process, and especially whether aerial imagery was interpreted correctly or biasedly. It should be remembered that point sampling of the total area was not performed purely randomly, but along sequences within tractor traces without fixed distances. Therefore, giving unconscious preference to specific sites may lead to biased sampling. Table 4 shows that the results are not 100 % identical: Map data overestimated erosion sites, especially in the strong - moderately eroded form, while normal (uneroded/uncolluviated) soils were underestimated. Colluviation, which is easier to detect both by the phenomena of soil borings and by aerial imagery, was estimated equally well by both methods. But more specifically, weak colluviation - on account of stronger forms - was underestimated by interpreting the aerial photos. This is evidence that free surveying by point samples tends to give preference to extreme and conspicuous sites.

As sums of landscape conditions, 60 % is eroded, 35 % is classified as normal and 5 % belongs to colluviated soils. Again, the large discrepancy between the extent of eroded and colluviated sites points to the openness of heavily eroded landscapes.

Table 4 Comparison of Map Data with Point Statistics

Erosion rating	Great Groups */	Map Data		Point Statistics	
		ha	%	ha	%
Weakly eroded	Do1, Do	43	14	56	16
Strong – moderately eroded	Kp1, Kp	148	48	152	43
Normal	Da, Tp, T, Tr	105	34	129	36
Weakly colluviated	H	9	3	13	4
Strong-moderately colluviated	Hc	3	1	3	1
Total		308	100	353	100

*/ Do1 : Oxic Dystropepts (krokos depths < 80 cm) Do : Oxic Dystropepts
Kp1 : Plinthic Kanhapludults (krokos depths < 40 cm) Kp : Plinthic Kanhapludults
Da : Aquic Dystropepts Tp : Plinthic Tropaquepts
T : Typic Tropaquepts Tr : Reductic Tropaquepts
H : Typic Humaquepts Hc : Cumulic Humaquepts

CONCLUSIONS

The aerial photo interpretation is a very useful method to delineate soil units on the map. A combination of aerial imagery, topographical maps and field observations provides the most effective approach for soil mapping in complex landscapes with simple soil patterns. Although the soil sampling was carried out relatively systematically according to relief form and the driving lanes of tractors, there was some agreement between point statistics and map data. The difference between both methods was maximally 3 %. The result combination from both methods showed that 60 % of the landscape was classified as eroded, 35 % as normal and only 5 % as colluviated. There was no balance of erosion and onsite sedimentation

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